U. S. NAVAL
PERSONNEL RESEARCH ACTIVITY
SAN DIEGO, CALIFORNIA 92152

TECHNICAL BULLETIN 65-9 MARCH 1965

EXPERIMENTAL EVALUATION OF PROGRAMED MATERIALS ON THE MULTIMETER AN/PSM-4 (U)

Alvin J. Abrams

NPRA
SAN DIEGO CALIFORNIA
AN ACTIVITY OF THE BUREAU OF NAVAL PERSONNEL

Submitted by

E. J. Pickering, Director, Basic Skills Research Department

Approved by

E. I. Jones, Ph.D., Director, Navy Training Research Laboratory
E. E. Dudek, Ph.D., Technical Director

G. W. WATSON, Commander, USN
Officer in Charge

T. A. No. 3.1703.01.03.2S2

U.S. Navy Training Research Laboratory
U.S. Naval Personnel Research Activity
San Diego, California 92152

ACKNOWLEDGEMENTS

Appreciation is expressed for the close cooperation received from the Commanding Officer and staff of the Fleet ASW School, San Diego. The cooperation of Lt. Robert D. Blatchely is particularly noted.

The assistance of Mr. R. L. Gillmer and R. J. Harrigan, FTCS, who provided technical information, and Mr. W. A. King and Mrs. G. E. White, who illustrated the programed text, is also gratefully acknowledged.

BRIEF

This report describes the development and evaluation of a programed text and a "programed instructor" presentation on the Multimeter AN/PSM-4, a commonly used piece of electronic test equipment. The programed materials were developed at the Navy Training Research Laboratory.

Eighty-one students at the Fleet ASW School, San Diego were used in the evaluation of the two programed methods. The students were divided into three groups: 31 were trained with the programed text, 16 were trained with the "programed instructor" presentation and 35 were trained by the conventional method. Performance of the groups was observed on a practical test one week after training.

The results revealed that: (1) Students who were trained with either of the programed methods performed better than those students who were trained by the conventional method. (2) Students learned to use the Multimeter AN/PSM-4 in its elementary applications with the programed text as the basic source of information. (3) It was feasible to use the programed text to introduce beginning technicians to the multimeter. (4) It was not feasible to use the "programed instructor" presentation.

CONTENTS

EXPERIMENTAL EVALUATION OF PROGRAMED MATERIALS ON THE MULTIMETER AN/PSM-4

A. The Problem and its Background

The need to improve the training of technicians in the use of electronic test equipments has often been recognized (1, 2, 3, 4, 5, 6,). For some time, the Navy Training Research Laboratory has been concerned with the development and experimental evaluation of improved training methods in this area. The results of a previous study (6), conducted with classes from the Basic Sonarman Course at the Fleet ASW School, San Diego, revealed that student performance improved significantly under an experimental training program. Two essential characteristics of the experimental training were: (1) More instructional emphasis was placed upon the operation of the equipment. (2) A procedure was developed for providing students, periodically, with relatively rapid and precise knowledge of results of their practical performance. Although performance improved significantly, the desired proficiency level was still not achieved. It is possible that performance would have been better had knowledge of results been more consistent, immediate, and precise. Since programed instructional techniques can provide consistent, immediate and precise knowledge of results, it was decided to explore the possibility of using programed materials to present necessary factual information and to provide students with structured practical experiences in using test equipment. As a point of departure, a programed text and a programed classroom demonstration--discussion ("programed instructor") presentation were developed on the Multimeter AN/PSM-4, a commonly used piece of test equipment. Four specific questions were considered in this investigation:

(a) Is it feasible to use a programed text in introducing beginning technicians to the Multimeter AN/PSM-4?

(b) Can students learn to perform elementary applications of Multimeter AN/PSM-4 when instruction is provided primarily by programed materials which include items requiring the use of this meter?

(c) Is it feasible to organize an instructor's presentation on the use of the Multimeter AN/PSM-4 in such a manner that students virtually are being trained by a "programed instructor?" (This method is described in detail later in the report.)

(d) Will students who are trained with either a programed text or by a "programed instructor" perform as well as students trained by conventional methods?

b. Use of illustrations. The program, particularly the first four sections, utilizes illustrations which are presented adjacent to each written page as a means of clarifying written information and presenting new information. (See Appendix A.) The correct answer to many items can be obtained only from these illustrations. An additional anticipated value of the illustrations was that they would acquaint trainees thoroughly with the appearance of the multimeter, especially the meter scales.

c. Review quizzes. Three paper and pencil review quizzes are contained in the program. The last quiz immediately precedes the practical performance section of the program. Each quiz is followed by a set of correct answers and a reference table which indicates the program items or sections which pertain to each quiz item. For each item which has been missed, the trainee is directed to review the specific items or sections of the text and to record the correct answer before proceeding. It is, thus, intended that on the quizzes the trainee will not only receive knowledge of results but that he will take immediate remedial action when necessary.

d. Programed practical performance. The last section of the text requires the trainee to perform 14 measurements; included are measurements of AC voltage, DC voltage, AC voltage in a mixed AC-DC voltage, current and resistance. In performing these measurements the Multimeter AN/PSM-4 is used with a simple power supply circuit which was designed specifically for the program. (See Appendix A, page 15.) The programed performance materials provide varying amounts of prompting on proper procedures as well as feedback on measurement results. The only type of measurement upon which information is presented in an earlier section but upon which practice is not provided with the test circuit is the measurement of high voltages or currents; i.e., voltage in excess of 300 VDC or 300 VAC or current in excess of 1000 MA. It was decided that since the students would be very inexperienced in measurement procedures and, additionally, they would be working without an instructor constantly nearby, the presence of voltage or current of such magnitude presented too great a risk.

2. Development of Materials for the Programed Instructor

The programed material for this presentation is basically a well structured set of questions, which follow an outline of the first four sections of the programed text. These questions constantly refer to a set of transparencies which were made from illustrations in the text. The programed text review quizzes and the practical work contained in the last section of the programed text are also used in this presentation. The presentation

that the instructor assignments were set by the School and could not be altered. In conducting this study within these limitations each class received instruction during the third day, and if necessary the morning of the fourth day of the third week of the Basic Sonarman Course. Individual performance criterion tests were administered one week later.

1. Composition of the Groups

Eighty-two subjects from four Basic Sonarman Course classes were used in this study; 31 students were trained with the programed text, 16 students were trained by the "programed instructor" and 35 students were trained by the conventional course method. While it was not possible to control assignments of students to each of the training conditions, the means and standard deviations presented in Table 1 reveal that there were only minor differences between the three groups in terms of scores on pertinent aptitude tests in the Navy Basic Test Battery.

2. Administration of the Training Methods

a. Programed text. Students were given the programed text by their regular instructor. A military member of the research staff was also present in the classroom to clarify any procedural difficulties which might arise and to observe student reaction to the program. The instructor opened the class period with a brief introduction to the program, and following this introduction he remained in the classroom to answer students' questions. (See Appendix C.) In answering questions, the instructor clarified procedures for working through the program or clarified program content by restating the material, but he did not clarify content by introducing new materials.

Some students finished the program in less than the six scheduled hours, but it was necessary to exceed this time limit for all to complete the program. The mean time on the program was 7 hours and 17 minutes with a standard deviation of 1 hour and 27 minutes, and a range from 3 hours to 9 hours and 15 minutes.[2]

b. "Programed instructor". This programed presentation was made to one class and then discontinued when it was found

[2]Three students in one class were forced to stop after 7 hours even though they had not completed the practical section of the program. All would have finished within a half hour, and it was decided to retain them in the sample for the performance criterion test.

as a control condition. The first four hours were lecture - demonstration on the meter movement and use of the meter. Students had meters with them during this presentation and the instructor used a large wooden mock-up of the meter face for demonstration purposes. The last two hours were spent in a laboratory on the measurement of resistance.

3. Experimental Results

a. Criterion performance test. As previously noted, students were given a performance test one week after training. This test required students to measure resistance, current, DC voltage, straight AC voltage, and the AC voltage portion of a mixed AC and DC voltage. These measurements were made at specific points on a TV chassis. Performance was observed individually and evaluated on a check list of 43 procedural steps. (See Appendix D.) Two criteria were used in evaluating the overall performance results; the average number of procedural errors, per student, which were made while performing the five measurements, and the average number of measurements, per student, which were made without any procedural errors.

Both kinds of criterion test scores are found in Appendix E, and it can be readily observed that these scores are not normally distributed. Consequently, the median, first and third quartile values and range are presented in Table 2. These values generally indicate that the students who took the programed text or who received the "programed instructor" presentation made fewer errors and performed more measurements without error than the students who received the conventional instruction, and that only minor differences are observed between the average performance in the two programed groups. The median student trained by either programed method performed approximately 90 percent of the procedural steps without error as compared to 82 percent for the median student trained under the conventional method. Additionally, 52 percent of the measurements made by the median student in the programed text group were made without procedural errors as compared to 41 percent of those made by the median student in the "programed instructor" group and 22 percent of the measurements made by the median student in the conventional group. It is also observed that 75 percent (Q3) of the students in the control group had worse scores on both criteria than the median student in either programed group.

The significance of differences in the criterion test performance of the programed and conventional groups was evaluated by the Mann-Whitney U test, which is a nonparametric composite rank analysis. The results of the U test, which are expressed in z scores, are presented in Tables 3 and 4. These results indicate that the differences on both criterion variables which favor the programed groups

over the conventional group were significant at the .01 level, while there was not a significant difference on either criterion between the two programed groups.

b. Program quizzes and programed text items. The programed text and the "programed instructor" groups took the first and second program review quizzes, while only the program text group took the final review quiz. The percentages of correct responses to each quiz, which are presented in Table 5, indicate that the mean percentages ranged from 81 to 92 for students who worked through the text, and that these students performed considerably better on quizzes A and B than did students who received the "programed instructor" presentation.

TABLE 4

Significance of Differences in the Number of Measurements Performed Without Procedural Error

Group	Group: Conventional (n=35)	Group: Programed Instructor (n=16)	Group: Programed Text (n=31)
Programed Text (n=31)	z=3.58**	z=.46	--
Programed Instructor (n=16)	z=2.77**	--	--

**Significant at .01 level

TABLE 5

Percentages of Correct Responses on Written Review Quizzes

Group	Quiz A (n=13 items)	Quiz B (n=43 items)	Quiz C (n=31 items)
Programed Text (n=31)	92	89	81
Programed Instructor (n=16)	64	74	-

D. Discussion and Conclusions

In the introduction to this report four questions were asked concerning the value and feasibility of the programed text and the "programed instructor" presentation. Based upon the results of this study the following general answers are presented: (1) Students who were trained with either of the programed methods performed with the multimeter better than those students who were trained by the conventional method; (2) Students did learn to use the Multimeter, AN/PSM-4, in its elementary applications with the programed text as the basic source of information, although not to a mastery level; (3) It was feasible to use the programed text to introduce beginning technicians to the multimeter; (4) It was not feasible to use the "programed instructor" presentation.

1. Performance Results Using the Multimeter

Three aspects of the criterion test results require discussion. First, in comparing the results of the three groups it should be remembered that training time was not held constant; the conventional group had two hours less training time than the "programed instructor" group and about one and a quarter hours less than the average for the programed text group. While this raises a legitimate question as to what degree the superior performance of either programed group was related to training time, it is felt that the major factor was the training method.

Second, it is apparent that none of the groups mastered the performance test in terms of the two performance criteria used in this study. The average student in the programed text group performed 90 percent of the necessary procedures without error and performed 52 percent of his measurements without committing a procedural error. Regarding this it should be noted that the proficiency of all groups would have appeared greater had the number of correct measurement results been used as a criterion. Measurement results often are accurate (within acceptable tolerance) despite the occurance of procedural errors.[3]

Third, although the programed group did not completely meet the training objectives of the program (see page 2), it is concluded that the program was of sufficient value to warrant its use with slight modification. The criterion test performance results

---

[3]Safety violations, a type of procedural error, endanger man or test equipment, but they may not affect the accuracy of the test result. Additionally, errors in selecting the meter range or in zeroing the meter do not invariably result in a large enough error to make the result inaccurate.

Sonarman Course at the Fleet ASW School, San Diego. Its use in Navy courses which teach the Multimeter AN/PSM-4 is recommended. Minor modifications might be of value.

2. It may also be feasible to program instruction for more complex electronic test equipments which are commonly used in the Navy.

APPENDIX A

EXAMPLE PAGES FROM THE PROGRAMED TEXT

The arrangement of illustrations and written pages in this appendix is as it was in the programed text. The illustration on the left hand page accompanies the program items on the right hand page.

PART I

PURPOSE OF THE MULTIMETER, AN/PSM-4

1. When a word begins with "multi" it means more than one. For example, the word multipurpose means more than one purpose, and a multicylinder motor is a motor with more than one cylinder. A piece of test equipment which incorporates more than one meter can thus be called a _____.

multimeter

---

2. The piece of equipment which is pictured on the opposite page is called a _____ ___/___ - .

Multimeter AN/PSM-4

---

3. As noted on the opposite page, this _____ incorporates an AC voltmeter, a DC voltmeter, an ohmmeter, and an ammeter. It is sometimes called a volt-ohm-milliammeter

multimeter

---

4. Because the Multimeter AN/PSM-4 incorporates an AC _____, a DC _____, an _____ and an _____ it is used to measure AC voltage, DC voltage, DC resistance, and DC current.

voltmeter
voltmeter
ohmmeter
ammeter

---

5. The Multimeter AN/PSM-4 is a volt-ohm-milliammeter which you will use in measuring AC _____, DC _____, DC _____, and DC _____.

voltage
voltage
resistance
current

---

6. An ammeter, which as you know is used only to measure current, _____ (is or is not) a multimeter.

is not

---

7. The Multimeter AN/PSM-4 contains _____ (how many?) meters and can be used for _____ (how many?) types of measurements.

four
four

(Program page 2)

AC voltage
DC voltage
DC current
DC resistance

8. The Multimeter AN/PSM-4 can be used for the following measurements: _____, _____, _____, and _____.

(No answer required.)

NOTE: Sound level measurements also can be made with this meter, but generally a different meter is used. This program does not consider sound level measurements. The procedure for such measurements is found in the Instruction Book for Multimeter AN/PSM-4A and AN/PSM-4B, NAVSHIPS 92051. (No answer required.)

PART II

IDENTIFICATION OF METER SCALES, CONTROLS, PLUG-IN JACKS AND LEADS

OHMS
DC
AC
2.5 VAC ONLY

9. Look at the illustration on the opposite page. On the upper half of the meter you find four scales and the meter pointer. You use these in reading results of measurements which you will learn to do later in the program. The scales are named _____, ____, ____, __·__ ___ ____.

---

meter pointer

10. When you make a measurement, the _____ _____ will indicate a point on a scale.

---

four

11. How many scales are located on the meter face? _____

---

ohms

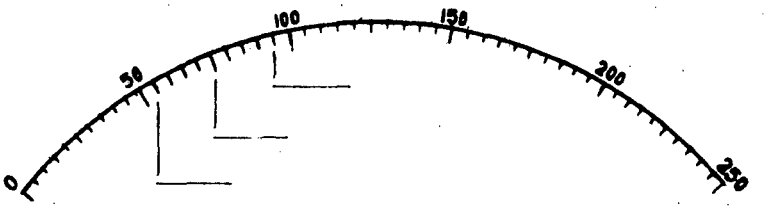
12. Just as the scale on your automobile speedometer makes it possible for you to know how many miles per hour you are traveling, the top scale on the AN/PSM-4 face makes it possible for you to find out how many _____ of resistance are being measured.

(Program page 4)

119. In the illustration on the left hand page you see how to determine values of the unlabeled markings for any range. Study the illustrations and proceed with this item.

a. When the 250V range is used, each marked interval from left to right on the DC scale represents an increase of _____ volts. Fill in the missing values.

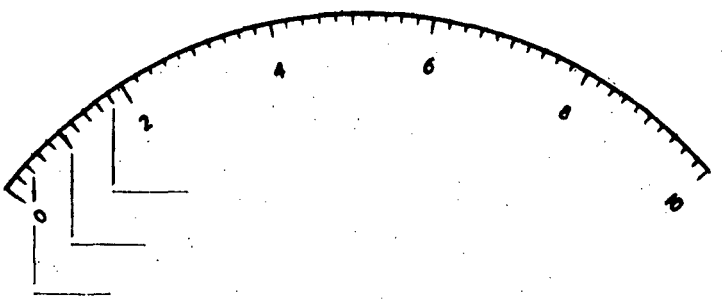
5



55, 75, 95

b. When the 100 MA range is used, each marked interval from left to right on the DC scale represents an increase of _____ MA. Fill in the missing values.

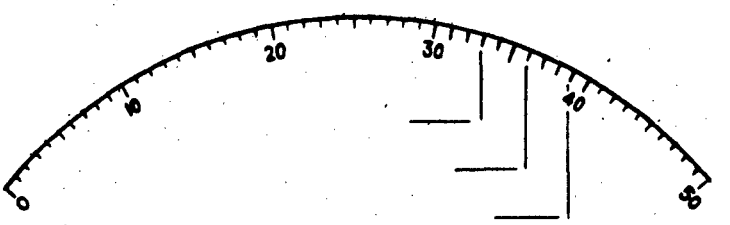
2



4, 10, 18

c. When the 5V range is used, each marked interval from left to right on the AC scale represents an increase of _____ volts. Fill in the missing values.

.1



3.3, 3.6, 3.9

(Program page 76)

PART V

USING THE METER

144. You have before you a Multimeter AN/PSM-4 and a special test circuit. You will now practice the four types of measurements (AC Voltage, DC Voltage, DC Current, and Resistance) that you can make with this multimeter. In your first set of measurements you can assume that all voltages are between zero and 500 volts and that the current is between zero and 1000 MA. This means that:

a. You will be inserting the Red test lead into the _____ meter jack in all of these measurements.

+V MA OHMS

b. You will start each voltage measurement with the RANGE SWITCH set in the _____ range and switch to _____ as required.

500V
lower

c. You will start each current measurement with the RANGE SWITCH set in the _____ range and switch to _____ ranges as required.

1000 MA
lower

NOTE: Unless a written answer is specifically requested, you are to respond to all items by performing the correct step. After you have performed each step, check the program answer to see whether your action was correct.

(No answer required.)

(No answer required.)

145. In the illustration on the adjacent page you see the sequence of steps which you will follow in all measurements. Let us start by measuring the positive DC voltage at test point 4 (TP 4) on the special test circuit. (If the test circuit is not energized turn the test circuit switch to the ON position.)

a. COMMON

+V MA
OHMS

a. First, insert the Black test lead in the _____ meter jack and the Red test lead into the _____ meter jack.

b. FUNCTION
DCV DIRECT

b. Next, set the _____ SWITCH to the position which is labeled _____.

c. RANGE
500V

c. Set the _____ SWITCH to the position which is labeled _____.

d. Black

Red

d. Now you are ready to connect the test leads to the circuit. First, insert the _____ test lead to ground. (ARE YOU USING ONLY ONE HAND AND HOLDING THE OTHER HAND BEHIND YOUR BACK?) Now, hold the insulated plastic portion of the _____ test lead and insert it in TP 4 which is the point of greater potential.

e. 0 - 50

lowest

e. Read the meter. With the RANGE SWITCH in the 500V position you should use the _____ reference range and multiply by ten. The meter needle barely deflects from the Zero position. YOU REMEMBER THAT THE MOST ACCURATE VOLTAGE READING IS MADE IN THE _____ RANGE WHICH STILL INCLUDES THE AMOUNT OF VOLTAGE BEING MEASURED. Since your reading at TP 4 is less than 10 volts but more than 5 volts, you should switch to the 10V range and repeat steps d and e of the measurement.

f. 10

6.5 (approximate)

f. Your reading at TP 4 with the RANGE SWITCH in the _____V range is _____VDC. (Record this reading.)

(No answer required.)

NOTE: Due to minor differences between test circuits and the effects of wear and tear on the components, only approximate readings can be provided in the answer column. (No answer required.)

APPENDIX B

EXAMPLES OF TRANSPARENCIES AND INSTRUCTOR'S TEXT FROM "PROGRAMED INSTRUCTOR" PRESENTATION

The illustrations on the left hand pages are the transparencies referred to in the instructor's text on the right hand pages.

TRANSPARENCY 15.

Let's also review the use of meter scales. Which meter scale would you use to read the results of each of the following measurements?

Measurement	Meter Scale (Answer)
a. Negative DC voltage	(DC)
b. Direct Current	(DC)
c. Straight AC voltage (assume 50 volts AC)	(AC)
d. Positive DC voltage	(DC)
e. Resistance	(OHMS)
f. An AC voltage (combined) which is superimposed upon a DC voltage level (assume 2.0 volts AC)	(2.5 VAC only)
g. Straight AC voltage (assume 1.75 volts AC)	(2.5 VAC only)
h. An AC voltage which (combined) is superimposed upon a DC voltage level (assume 6.0 volts AC)	(AC)

Thus far you have learned when you will use each of the four meter scales, and what you can measure with the FUNCTION switch in each of its positions. Now we turn to another impprtant meter control -- the RANGE SWITCH.

THE RANGE SWITCH IS USED TO SELECT THE VOLTAGE OR CURRENT RANGE IN WHICH YOU CAN MAKE THE MOST PRECISE MEASUREMENT OF AN AC VOLTAGE, A DC VOLTAGE OR A DIRECT CURRENT.

Transparency 17.

What is the RANGE SWITCH used for?
(Answer: To select a voltage or current range in which you can make the most precise measurement of AC voltage, DC voltage or Direct Current).

Transparency 19.

Each voltage or current range identifies the maximum amount, largest or highest amount of voltage or current that can be measured in that range. If you try to measure too large of a current or voltage for a given range you will damage the multimeter.

This RANGE SWITCH (point to TR 19) is in which range?
(Answer: 10 MA).

Can you measure more than 10 MA in this range?
(Answer: No.).

Can you measure 15 VAC if the meter is in the:

a. 2.5 V range? (No)

b. 5 V range? (No)

c. 10 V range? (No)

d. 25 V range? (Yes)

You have now learned the important things about the RANGE SWITCH. Let's review:

a. For what types of measurements will you use it?
(Answer: AC voltage, DC voltage, Direct Current).

b. For what type of measurement is it not used?
(Answer: Resistance).

c. What does the value of each range signify?
(Answer: The maximum value that can be measured in that range).

APPENDIX C

INSTRUCTIONS TO INSTRUCTOR FOR ADMINISTERING PROGRAMED TEXT

A. When introducing the program stress the following points:

1. The program is a "self teaching" book that enables the student to work at his own pace. This means that faster students can work more rapidly and slower students can take longer. The important thing is that each student works at his own pace. This doesn't mean loaf, it means that the student keeps moving but only as he understands what he is doing.

2. It will take students between 4 and 8 hours to complete the program.

3. The AN/PSM-4 is a very common piece of test equipment which the student will be using later in the course and out in the fleet. It is a very important tool in sonar maintenance.

4. Show the test circuit and mention that the last part of the program involves making measurements on the circuit.

5. The answers to all program items have been presented in previous items or can be found by studying illustrations. Students should ask for help if they get stuck. Also, students' answers do not have to be worded exactly the same as the answers in the program answer column.

B. While students are working on the program:

1. Help any student who gets stuck, but give as quick and simple an answer as possible. Try to get the student back on to the program so that he gets explanation of new ideas from the program.

2. Periodically move through the class and make sure that students are using their answer cover properly.

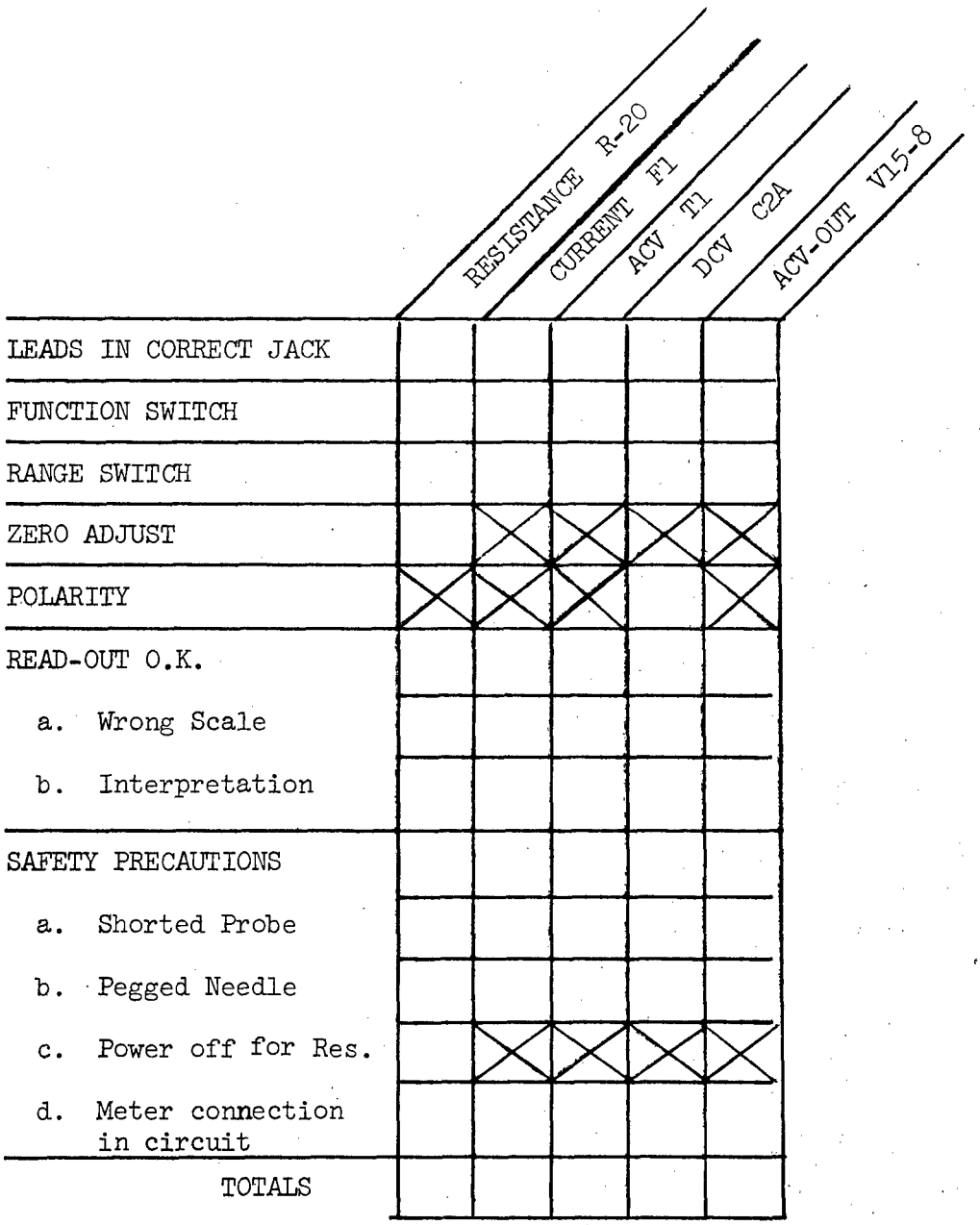
C. When students are ready to start the practical section:

1. Tell students that their meter should be laying down while they make measurements.

2. Introduce the test circuit by mentioning that it is a power supply, and that they will learn more about power supplies later.

APPENDIX D

CRITERION TEST PERFORMANCE CHECK LIST



APPENDIX F

PERCENTAGES OF ITEMS AND SUBITEMS BY PERCENTAGES OF CORRECT STUDENT RESPONSES

Cumulative Percentages of Program Items and Subitems		Percentages of Correct Student Responses
34.5	of items answered correctly by	100%
61.0		97
75.5		94
86.5		90
92.0		87
94.5		84
96.0		81
98.0		77
98.5		74
99.5		68
100		58